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UTILITY PATENT APPLICATION TRANSMITTAL

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09/617569

ADDRESS TO:

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Box Patent Application
Washington, D.C. 20231

Attorney Docket No. 204133
First Named Inventor Roelvink, Petrus W.
Express Mail No. EK506503906US

APPLICATION ELEMENTS

1. ☒ Utility Transmittal Form
2. ☒ Specification (including claims and abstract) [Total Pages 20]
3. ☐ Drawings [Total Sheets]
4. ☐ Combined Declaration and Power of Attorney [Total Pages]
 - a. ☐ Newly executed
 - b. ☐ Copy from prior application [Note Box 5 below]
 - i. ☐ Deletion of Inventor(s) Signed statement attached deleting inventor(s) named in the prior application
5. ☐ Incorporation by Reference: The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Microfiche Computer Program
7. ☐ Nucleotide and/or Amino Acid Sequence Submission
 - a. ☐ Computer Readable Copy
 - b. ☐ Paper Copy
 - c. ☐ Statement verifying above copies

ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet and document(s))
9. ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☒ Information Disclosure Statement (IDS)
 - ☒ Form PTO-1449
 - ☒ Copies of References AA-AS
12. ☐ Preliminary Amendment
13. ☒ Return Receipt Postcard (Should be specifically itemized)
14. ☒ Small Entity Statement(s)
 - ☒ Enclosed
 - ☐ Statement filed in prior application; status still proper and desired
15. ☐ Certified Copy of Priority Document(s)
16. ☒ Other: PrintEFS Patent Application Bibliographic Data Output

17. If a **CONTINUING APPLICATION**, check appropriate box and supply the requisite information in (a) and (b) below:
- (a) ☐ Continuation ☐ Divisional ☐ Continuation-in-part of prior application Serial No. _____
Prior application information: Examiner _____; Group Art Unit: _____
- (b) Preliminary Amendment: Relate Back - 35 USC §120. The Commissioner is requested to amend the specification by inserting the following sentence before the first line:
"This is a ☐ continuation ☐ divisional of copending application(s)
☐ Serial No. _____, filed on _____
☐ International Application, filed on _____, and which designates the U.S."

APPLICATION FEES


BASIC FEE				\$ 690.00
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total Claims	43 - 20 =	23	x \$18.00	\$ 414.00
Independent Claims	4 - 3 =	0	x \$78.00	\$ 78.00
<input type="checkbox"/> Multiple Dependent Claims(s) if applicable			+ \$260.00	\$ 0.00
Total of above calculations =				\$1,182.00
Reduction by 50% for filing by small entity =				\$ 591.00
<input type="checkbox"/> Assignment fee if applicable			+ \$40.00	\$ 0.00
TOTAL =				\$ 591.00

UTILITY PATENT APPLICATION TRANSMITTAL

Attorney Docket No. 204133

19. ☒ Please charge my Deposit Account No. 12-1216 in the amount of \$ 591.00.
20. ☐ A check in the amount of \$ is enclosed.
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- a. ☒ Fees required under 37 CFR §1.16.
- b. ☒ Fees required under 37 CFR §1.17.
22. ☒ The Commissioner is hereby generally authorized under 37 CFR §1.136(a)(3) to treat any future reply in this or any related application filed pursuant to 37 CFR §1.53 requiring an extension of time as incorporating a request therefor, and the Commissioner is hereby specifically authorized to charge Deposit Account No. 12-1216 for any fee that may be due in connection with such a request for an extension of time.

23. CORRESPONDENCE ADDRESS

<input checked="" type="checkbox"/> Customer Number: 23460  23460 PATENT TRADEMARK OFFICE	<input type="checkbox"/> , Reg. No. Leydig, Voit & Mayer, Ltd. Two Prudential Plaza, Suite 4900 180 North Stetson Chicago, Illinois 60601-6780 (312) 616-5600 (telephone) (312) 616-5700 (facsimile)
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Name	M. Daniel Hefner, Registration No. 41,826
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Signature	
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Date	July 17, 2000
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Certificate of Mailing Under 37 CFR §1.10

I hereby certify that this Utility Patent Application Transmittal and all accompanying documents are being deposited with the United States Postal Service "Express Mail Post Office To Addressee" Service under 37 CFR §1.10 on the date indicated below and is addressed to: Assistant Commissioner for Patents, Box Patent Application, Washington, D.C. 20231.

		July 17, 2000
Name of Person Signing	Signature	Date

jc813 U.S. PTO
07/17/00

PATENT
Attorney Docket No. 204133

Applicant or Patentee: Roelvink et al.
Application or Patent No.
Filed or Issued: July 17, 2000
For: ANTIGENIC COMPOSITIONS AND METHODS

VERIFIED STATEMENT (DECLARATION)
CLAIMING SMALL ENTITY STATUS
37 C.F.R. §§ 1.9(f) & 1.27(c) - SMALL BUSINESS CONCERN

I hereby declare that I am:

- ☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

Name of Concern: **GenVec, Inc.**
Address of Concern: **65 West Watkins Mill Road**
Gaithersburg, Maryland 20878

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 C.F.R. § 121.3-18, and reproduced in 37 C.F.R. § 1.9(d), for purposes of paying reduced fees under Sections 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement: (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time, or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either directly or indirectly one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled: ANTIGENIC COMPOSITIONS AND METHODS, by inventors Petrus W. Roelvink, Imre Kovesdi, Joseph T. Bruder, Douglas E. Brough, Duncan McVey L. McVey, and Thomas J. Wickham, as described in:

- ☒ The specification filed herewith.
☐ Application No. , filed .
☐ Patent No. , issued .

Others Having Rights In The Invention

If the rights held by the above-identified small business concern are not exclusive, each individual, concern, or organization having rights in the invention is listed below and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 C.F.R. § 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 C.F.R. § 1.9(d), or a nonprofit organization under 37 C.F.R. § 1.9(e). (NOTE: Separate verified statements are required from each named person, concern, or organization having rights to the invention averring to his/her/its status as a small entity.)

Name:

Address:

☐ Individual ☐ Small Business Concern ☒ Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 C.F.R. § 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Name of Person Signing: **Paul H. Fischer**
Title in Organization: President and CEO
Address of Person Signing: 65 West Watkins Mill Road
Gaithersburg, MD 20878

Paul H Fischer
Signature

July 13, 2000
Date

Tissue (mg)		Concentration (mg/g)		Total (mg)		Residue (mg)		Loss (mg)		Recovery (%)	
1	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
2	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
3	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
4	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
5	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
6	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
7	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
8	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
9	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
10	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
11	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
12	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
13	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
14	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
15	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
16	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
17	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
18	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
19	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
20	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
21	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
22	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
23	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
24	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
25	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
26	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
27	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
28	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
29	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
30	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
31	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
32	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
33	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
34	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
35	100	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0	100	100
36	100										

CORRESPONDENCE INFORMATION

APPLICATION INFORMATION

Title Line One:: ANTIGENIC COMPOSITIONS AND METHODS

Formal Drawings?: No
Docket Number:: 204133
Secrecy Order in Parent Appl.?: No

REPRESENTATIVE INFORMATION

Representative Customer Number:: 23460

CONTINUITY INFORMATION

This application is a:: NON PROV. OF PROVISIONAL
> Application One:: 60/181,289
Filing Date:: 02-09-2000

Source:: PrintEFS Version 1.0.1

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ANTIGENIC COMPLEXES AND METHODS

CROSS REFERENCE TO RELATED APPLICATION

The present patent application claims priority to U.S. Provisional Patent
5 Application No. 60/181,289, filed February 9, 2000.

TECHNICAL FIELD OF THE INVENTION

The present invention pertains to antigenic complexes and methods of
inoculating and immunizing animals.

10

BACKGROUND OF THE INVENTION

The identification of pathogenic organisms and viruses has led to the
development of successful protocols for immunizing healthy individuals against
such organisms. Early protocols involved exposing healthy individuals to live or
15 attenuated pathogens to induce immune responses against the pathogens. With
respect to many pathogens, such live or attenuated vaccines remain superior to
other vaccines because of their tendency to elicit a broad level protective response.
Other disorders, however, are caused or spread by pathogens less amenable to this
approach. For example, it has proven difficult to develop or store live or
20 attenuated vaccines derived from several common pathogens. Still other
pathogens simply are not sufficiently antigenic to generate a sufficient (or even
any) response in a host animal to be useful as a vaccine, whether through evolved
stealth defenses (e.g., HIV, herpes, etc.), limited presentation of antigen,
genetic drift (e.g., influenza), or other proclivities. Of course, the possibility of
25 actually causing the disease against which protection is intended (e.g., polio,
measles, etc.) remains a major concern associated with this approach.

An alternative to the use of live/attenuated pathogen vaccines is to use
antibodies raised against antigens associated only with an identified pathogen.
Such approaches can be effective in some instances. However, no assurance can
30 be had that any antibodies raised against a putative antigen will effectively protect
against the pathogen providing the antigen. Thus, it is frequently necessary to test
a large number of putative antigens isolated from a pathogen, rendering such
approaches relatively costly and time consuming. Also, such approaches generally
do not elicit the broad level of protective response associated with live vaccines.

35 Genetic or peptide immunization has emerged as an alternative to
conventional vaccines. This technology involves inoculating DNA encoding a
pathogen protein, or an isolated pathogen protein, into the host. Risk of infection

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is greatly reduced, and the DNA or protein vaccines can be delivered to cells not normally infected by the pathogen. Compared to conventional vaccines, the production of DNA or peptide vaccines is straightforward, and DNA and protein are considerably more stable than live/attenuated vaccines. However, some DNA or protein vaccines are not effective against certain pathogens. Indeed, vaccine approaches that deliver entire proteins may direct the immune response against immunodominant epitopes only, and not against subdominant epitopes (e.g., EBV latent membrane protein). Alternatively, such approaches can direct an immune response against epitopes subject to antigenic variation, and in some instances, such approaches can actually result in tolerance to the pathogen (e.g., a tumor or a microbe), rather than immunity (see, e.g., Toes *et al.*, *Proc. Nat. Acad. Sci. (USA)* 94, 14660-65 (1997); Toes *et al.*, *Proc. Nat. Acad. Sci. (USA)*, 93, 7855-60 (1996); Toes *et al.*, *J. Immunol.*, 156, 3911-18 (1996); Aichele *et al.*, *Proc. Nat. Acad. Sci. (USA)*, 91, 444-48 (1994); Aichele *et al.*, *J. Exp. Med.*, 182, 261-66 (1995)).

Other recent advances in vaccine technology have focused on the manner in which cellular immunity is acquired in the first instance. Recognition and destruction of at least some pathogens is performed principally by CD8⁺ cytotoxic T lymphocytes (CTLs). The mounting of a CTL immune response requires that “foreign” proteins undergo intracellular processing to peptide fragments, a function performed with high efficiency by professional antigen presenting cells (APCs), such as B-cells, dendritic cells, lymphoid fibroblasts, Langerhans cells, macrophages, monocytes, peripheral blood fibrocytes, etc., and potentially other cells such as cortical thymus epithelial cells, Ia- Thy 1- cells, peritoneal exudate cells, and the like. The processed peptide fragments ultimately are presented at the cell surface complexed with major histocompatibility complex (MHC) class I molecules, which constitute the first stimulatory signals recognized by a CTL.

Processing of antigens presented by class I MHC generally involves endogenous synthesis and cytoplasmic processing not involving endosomes. While, under some circumstances, exogenous antigens can enter the cytoplasm for processing by the nonendosomal pathway and presentation by class I MHC, typically, exogenous antigens are internalized and processed through endosomes for presentation by class II MHC. To exploit this biology, APCs pulsed with proteins or DNA have been employed in vaccines. Typically, dendritic cells are harvested and pulsed with the protein or DNA and then cultured to activate MHC-I or MHC-II responses. These cells can be used subsequently *in vivo* or *in vitro* to present the antigens to CTLs. While these approaches may prove promising, a matter of concern when using APCs as carriers is that isolating even limited

amounts of such cells is labor-intensive. Moreover, MHC class II-deficient APCs, expressing only MHC-I often fail to induce protection (Schnell *et al.*, *J. Immunol.*, 164(3), 1243-50 (2000)). This demonstrates the desirability of achieving both types of response.

5 In addition to the limitations of current vaccine technologies, the identification of suitably antigenic proteins, peptides, or other moieties from many species of pathogen remains elusive. Considering these, and other, drawbacks, a need remains for improved strategies for identifying suitable antigens and for using them to inoculate animals.

10

BRIEF SUMMARY OF THE INVENTION

The present invention provides a complex that includes a virion having a ligand that recognizes an epitope present on an immune effector cell surface and at least a first nucleic acid encoding a first non-native antigen. The invention also
15 provides a library including a plurality of such complexes, in which antigens of at least two of the plurality are different.

Such reagents are useful both in research and in the clinic. Thus, for example, the invention provides a method of precipitating an immune response within an immune effector cell, wherein such a complex is delivered to the cell
20 under conditions sufficient for the cell to mount an immune response to the antigen. When applied *in vivo*, the method can serve to immunize an animal from the pathogen. Moreover, using a library including a plurality of complexes, which contains at least one test antigen, the invention provides a method of assessing the antigenicity of the test antigen. These and other aspects of the present invention,
25 as well as additional inventive features, will be apparent upon reading the following detailed description.

DETAILED DESCRIPTION OF THE INVENTION

Within the inventive complex, the ligand on the virion typically (but need
30 not be) proteinaceous. Examples of suitable ligands include (but are not limited to) short (e.g., about 6 amino acids or less) linear stretches of amino acids recognized by integrins, as well as polyamino acid sequences such as polylysine, polyarginine, etc. Inserting multiple lysines and/or arginines provides for recognition of heparin and DNA, and an RGD sequence can be used as a ligand to
35 bind integrins, such as are present on immune effector cells. Tandem repeats of lysine, arginine, and/or histidine residues (e.g., three or more, five or more, or even as many as ten or more tandem lysine residues, tandem arginine residues, tandem

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histidine residues, or tandem mixtures of lysine or histidine) can be similarly employed. Other ligands can be specific for particular substrates, such as, for example, immunoglobulin-like molecules (e.g., FABs, ScABs, etc.), or known specific ligands (e.g., CD40L that recognizes the CD40 antigen). Thus, it will be
 5 apparent that, in some embodiments, the ligand is native to the virion (i.e., being present in a wild-type virus from which the virion is derived), but in other embodiments the ligand is a non-native ligand.

The ligand can be any moiety that binds with relative specificity to a substrate present on the surface of an immune effector cell (e.g., a T-lymphocyte
 10 or a B-lymphocyte, a natural killer cell, a granulocyte, a macrophage, a monocyte, a polymorphonucleocyte, a dendritic cell, etc.). Such a cell surface binding site can be any suitable type of molecule, but typically is a protein (including a modified protein such as a glycoprotein, a mucoprotein, etc.), a carbohydrate, a proteoglycan, a lipid, a mucin molecule, or other similar molecule. Examples of
 15 potential cell surface binding sites include, but are not limited to, heparin and chondroitin sulfate moieties found on glycosaminoglycans; sialic acid moieties found on mucins, glycoproteins, and gangliosides; and common carbohydrate molecules found in membrane glycoproteins, including mannose, N-acetyl-galactosamine, N-acetyl-glucosamine, fucose, and galactose. As immune
 20 effector cells typically are classified by the presence of various cell-surface proteins, many suitable proteins are known in the art.

The inventive complex is useful for eliciting an immune response within a derived (i.e., target) immune effector cell, typically an APC. In many applications, dendritic cells are preferred target APCs because using the CD40 ligand (CD40L)
 25 as a targeting ligand also facilitates the priming of CD8⁺ cells (see, e.g., Toes *et al.*, *Sem. Immunol.*, 10, 443-48 (1998)), further enhancing the efficacy of the invention. Where dendritic cells are the desired target, the ligand can recognize a protein typically found on dendritic cell surfaces such as adhesion proteins, chemokine receptors, complement receptors, co-stimulation proteins, cytokine
 30 receptors, high level antigen presenting molecules, homing proteins, marker proteins, receptors for antigen uptake, signaling proteins, virus receptors, etc. Examples of such potential ligand-binding sites in dendritic cells include 2A1, 7-TM receptors, CD1, CD11a, CD11b, CD11c, CD21, CD24, CD32, CD4, CD40, CD44 variants, CD46, CD49d, CD50, CD54, CD58, CD64, ASGPR, CD80,
 35 CD83, CD86, E-cadherin, integrins, M342, MHC-I, MHC-II, MIDC-8, MMR, OX62, p200-MR6, p55, S100, TNF-R, etc. Preferably, where dendritic cells are targeted, the ligand recognizes the CD40 cell surface protein, such as, for example,

a CD-40 (bi)specific antibody fragment or a domain derived from the CD40L polypeptide.

Where macrophages are the desired target, the ligand can recognize a protein typically found on macrophage cell surfaces, such as phosphatidylserine
 5 receptors, vitronectin receptors, integrins, adhesion receptors, receptors involved in signal transduction and/or inflammation, markers, receptors for induction of cytokines, or receptors up-regulated upon challenge by pathogens, members of the group B scavenger receptor cysteine-rich (SRCR) superfamily, sialic acid binding
 10 receptors, members of the Fc receptor family, B7-1 and B7-2 surface molecules, lymphocyte receptors, leukocyte receptors, antigen presenting molecules, and the like. Examples of suitable macrophage surface target proteins include, but are not limited to, B7-1, B7-2, CD11c, CD13, CD16, CD163, CD1a, CD22, CD23, CD29, Cd32, CD33, CD36, CD44, CD45, CD49e, CD52, CD53, CD54, CD71, CD87, CD9, CD98, Ig receptors, Fc receptor proteins (e.g., subtypes of Fc α , Fc γ , Fc ϵ , etc.), folate receptor β , HLA Class I, Sialoadhesin, siglec-5, and the toll-like
 15 receptor-2 (TLR2).

Where B-cells are the desired target, the ligand can recognize a protein typically found on B-cell surfaces, such as integrins and other adhesion molecules, complement receptors, interleukin receptors, phagocyte receptors, immunoglobulin
 20 receptors, activation markers, transferrin receptors, members of the scavenger receptor cysteine-rich (SRCR) superfamily, growth factor receptors, selectins, MHC molecules, TNF-receptors, and TNF-R associated factors. Examples of typical B-cell surface proteins include β -glycan, B cell antigen receptor (BAC), B7-2, B-cell receptor (BCR), C3d receptor, CD1, CD18, CD19, CD20, CD21, CD22, CD23, CD35, CD40, CD5, CD6, CD69, CD71, CD79a/CD79b
 25 dimer, CD95, endoglin, Fas antigen, human Ig receptors, Fc receptor proteins (e.g., subtypes of Fc α , Fc γ , Fc ϵ , etc.), IgM, gp200-MR6, Growth Hormone Receptor (GH-R), ICAM-1, ILT2, CD85, MHC class I and II molecules, transforming growth factor receptor (TGF-R), α 4 β 7 integrin, α iib β 3 integrin, α L β 2 integrin,
 30 and α v β 3 integrin.

Where fibrocytes are the desired targets, the ligand can recognize a protein found on fibrocyte cell surfaces such as major histocompatibility complex molecules, co-stimulatory molecules, and adhesion molecules, such as, for
 35 example, CD11a, CD13, CD34, CD45, CD54, CD58, CD80, CD86, HLA –DQ, HLA –DR, HLA-DP, and MHC-I and -II molecules. Of course, other cell types can be similarly targeted using domains known to be present within the surfaces of the desired cell.

In addition to the virion having the ligand, the complex also includes a (i.e., at least one) nucleic acid encoding a first non-native antigen. The antigen is “non-native” in that it is not present on a wild-type virus corresponding to the source from which the virion is derived. With this stricture in mind, the antigen can be any moiety to which it is desired to effect an immune response. Typically, the antigen is an antigenic peptide derived from a pathogen (e.g., a virus, a bacterium, a spore or fungus, a parasite, etc.) or from a cancerous cell. Examples of some suitable antigens include, but are not limited to, viral antigens (e.g., from HIV GP120, Env, gag, pol or nef proteins or polypeptides, EBV latent membrane protein, etc.), endoglin, and tumor-associated antigens (TAAs) (e.g., BAGE, carcinoembryonic antigen (CEA), CASP-8, β -catenin, CDK-1, ESO-1, gp75, gp100, MAGE-1, -2, and -3, MART-1, mucins (MUC), MUM-1, p53, PAP, PSA, PSMA, ras, tyrosinase, trp-1 and -2, etc.). In another embodiment, an antigen can be a synthetic polypeptide (e.g., an HLA-A2-restricted gp100 peptide (see, e.g., Rosenberg *et al.*, *Nat. Med.*, 4, 321-27 (1998))). For example, such an antigenic polypeptide can include a series of antigenic epitopes, such as between about 1 and about 15 (e.g., between about 5 and 10) such antigenic epitopes. Indeed, the antigenic properties of the inventive vaccine can be enhanced against that pathogen by using such synthetic antigens having epitope domains derived from the same pathogen. To facilitate processing and proper presentation, preferably each of such domains contains between about 5 and about 10 amino acids (e.g., about 8 amino acids) and/or is separated from other domains by polyamino acid spacers (e.g., polyalanine). Similarly, antigenicity also can be enhanced where the complex includes a plurality of such nucleic acids (i.e., encoding more than one first antigen).

Expression of the nucleic acid encoding the first antigen within the immune effector cells can permit the stimulation of an MHC-I response against the antigen. Moreover, in some embodiments, it is desirable for the complex to have a plurality of nucleic acids encoding antigens (e.g., to stimulate immune responses against multiple sites on a pathogen or to stimulate immune responses against multiple pathogens). Thus, the nucleic acid preferably is expressed within immune effector cells, and more preferably APCs. To facilitate expression, the nucleic acid encoding the first antigen is operably linked to a promoter that is active within the desired immune effector cell.

Preferably, in addition to the ligand and the nucleic acid encoding the first antigen, the complex also includes at least one second non-native antigen. This antigen can, as is the case for the ligand, be displayed on the surface of the virion,

but it need not be so displayed (e.g., it can be a latent antigen), so long as it elicits an immune response. The second antigen can be any suitable antigenic moiety, such as those set forth above. The presence of the second antigen can facilitate an MHC-II response against the antigen. In many embodiments, to enhance the potency of the immune response, the first (i.e., encoded) antigen(s) and the second (i.e., surface) antigen(s) are derived from the same pathogen. Such a strategy facilitates the generation of both an MHC-I and MHC-II response to the pathogen. In this respect, a particularly preferred embodiment is for at least one first antigen to be the same as at least one second antigen.

To facilitate attachment of the ligand to the desired cell, the ligand should be displayed on the surface of the virion within the complex. Suitable display can be accomplished by any desired means. For example, the ligand can be a domain present within a bi- or multi-specific protein (e.g., a bi-specific antibody), another domain of which selectively binds to a moiety present on the virion. In another embodiment, the ligand can be integrally connected to the virion. For example, the virion can include at least one chimeric protein having at least one first domain derived from a viral capsid protein and at least one-second domain comprising the ligand. Within such chimeric proteins, the viral capsid protein domains, as well as the ligand domains, can be full length or truncated. Of course, the virion can include a plurality of such proteins. In yet another embodiment, the ligand can be chemically conjugated to the virion by methods known in the art.

The virion is composed of viral capsid proteins, and it can be, but it need not be, an intact virus. Indeed, the virion can be a virus-like particle (VLP), empty capsid, or other viral-derived structure that has a lumen and a surface. However, preferably the virion is an intact virus, in which instance the nucleic acid encoding the first nucleic acid comprises a viral genome, typically also including encoding one or more of the viral capsid proteins making up the virion. Where the nucleic acid is a viral genome, it need not be complete, and, indeed, for many applications, the genome preferably contains one or more mutations interfering with viral replication. In some embodiments, the vector most preferably is replication incompetent except in packaging cells. Any suitable manipulation of the viral genome can be applied to achieve this end, many of which are known in the art. Thus, for example, where the virion and nucleic acid constitute an adenovirus, it can have replication-inactivating mutations, e.g., within the E1a, E1b, E2, and/or E4 regions of the genome. Similarly, where the virus is HSV, it can have inactivating mutations in one or more immediate early genes (e.g., ICP4, ICP27, ICP0) to render it replication incompetent. In other embodiments, for example

where mimicry of a live virus is desired, it is desirable for the virus to be replication competent.

Structurally, the virion can be enveloped or non-enveloped, and it can be derived from any desirable type of virus. Preferably, the virion is derived from a virus useful as a gene-transfer vector, such as, for example, herpesviruses (e.g., Herpes Simplex, Epstein-Barr, pox, etc.), adenoviruses, adeno-associated viruses (AAV), and other viruses known in the art. As considerable advances have been made in engineering functional chimeric adenoviral coat proteins, in embodiments in which ligands and/or second antigens are desired to be integral with the virion, preferably the virion is derived from an adenoviral capsid. In this respect, any chimeric protein desirably has at least one domain representing the ligand (or second antigen) and at least one other domain derived from an adenoviral coat protein (e.g., fiber, hexon, penton, pIIIa, pVI, pIX).

To further direct the virion to the desired immune effector cells, preferably its natural tropism for other types of cells is attenuated or eliminated. Methods suitable for attenuating native viral tropism are known in the art. For example, adenoviral-based virions can have one or more mutant adenoviral fiber protein(s) exhibiting reduced affinity for a native adenoviral cellular receptor (see, e.g., International Patent Application WO 98/54346 (Wickham *et al.*)). Moreover, an adenovirus-derived virion can include one or more recombinant penton base protein(s) lacking a native RGD sequence to reduce cell binding via α_v integrins (see, e.g., U.S. Patents 5,559,099 (Wickham *et al.*) and 5,731,190 (Wickham *et al.*)). Similarly, an adenovirus-derived virion can include one or more recombinant hexon(s) lacking a native sequence (e.g., HVR) to reduce its ability to be recognized by a neutralizing antibody (see, e.g., International Patent Application WO 98/40509 (Crystal *et al.*)). In other embodiments, a herpesvirus-derived virion can have mutant envelope glycoproteins lacking cell-surface ligands (see, e.g., International Patent Application WO 99/06583 (Glorioso *et al.*)).

Preferably, the immune response elicited against the complex is specific to either the first (i.e., surface) and/or second (i.e., encoded) antigen(s). Thus, the virion preferably elicits less virion-specific immunogenicity in a host animal than does a corresponding wild-type virion. To facilitate this, the virion can be engineered to lack a native immunodominant epitopes, such as are present in adenovirus, for example, on the viral hexon protein (see, e.g., International Patent Application WO 98/04509). Similarly, the virus can be engineered to lack one or more glycosylation or phosphorylation site(s). Alternatively, the virion can be conjugated to a lipid derivative of polyethylene glycol comprising a primary amine

group, an epoxy group, or a diacylglycerol group. Without being bound by any particular theory, such modifications are believed to mask the virion, at least in part, from scavenging, particularly by the cells of the reticulo-endothelial system.

Regardless of whether the virion is an intact virus or a VLP, the complex is
 5 useful for delivering the nucleic acid to an immune effector cell such that the nucleic acid is expressed within the immune effector cell to produce the first antigen. To facilitate this, the complex can include adjunct constituents for facilitating transduction of the cells (e.g., one or more liposomes), and the presence of such adjuncts is preferred when the virion is other than an intact virus. To
 10 further promote immune activation, the complex can include at least one second nucleic acid sequence encoding a factor that activates an immune effector cell. For example, the factor can be a cytokine, such as granulocyte colony stimulating factor (CSF), monocyte CSF, granulocyte and monocyte CSF, interleukins 1-12, tumor necrosis factor- α or - β , macrophage inflammatory protein (MIP)-1- α or - β ,
 15 MIP-2, interferon- γ (IFN- γ), etc. In embodiments where dendritic cells, macrophages, or other APCs are the targeted immune-effector cells, the factor can be CD40-L or osteopontin (or active fragments of these proteins), as these accentuate IL-12 and attenuate IL-10, which is associated with activation of the CD40 protein and the specificity of the response through initiation of the TH-1 and
 20 TH-2 subsets. Similarly, the second nucleic acid can encode a superantigen (e.g., a protein, such as are found on some bacteria, that prime cells of the immune system). In other embodiments, the second nucleic acid can encode an anticancer agent, e.g., a cytokine, an enzyme that converts a prodrug to a toxin (e.g., HSV tk), an apoptotic or an anti-angiogenic agent, many of which are known in the art.

25 The second nucleic acid can be present within a larger nucleic acid molecule that also includes the first nucleic acid (which is typically the case, where the capsid or virion includes an intact virus), or the two nucleic acid molecules can be within different nucleic acids, if desired. Of course, the second nucleic acid should be operably linked to a promoter sufficient to drive expression of the
 30 encoded factor within the desired immune effector cells, as described above. As with the first nucleic acid, any suitable promoter can be employed with respect to the second nucleic acid, such as a constitutive promoter (e.g., a viral immediate early promoter), a tissue-specific promoter, a regulatable promoter (e.g., metallothionin promoter, tetracycline-responsive promoter, RU486-responsive
 35 promoter, etc.), or other desired promoter. Indeed, the first and second nucleic acids can share the same promoter, such as, for example, separated by internal ribosome entry sites (IRES). In another embodiment, the first and second nucleic

acids are on opposite sides of a strong bi-directional promoter, many of which are known in the art (see, e.g., Lee *et al.*, *Mol Cells.*, 10(1), 47-53 (2000), Dong *et al.*, *J. Cell. Biochem.*, 77(1), 50-64 (2000), and Li *et al.*, *J. Cell. Biochem.*, 273(43):28170-7 (1998)).

5 The complex can be made by standard methods. Typically, the virions are constructed by producing viral capsid or coat proteins within packaging cells appropriate for the type of virus (e.g., HEK 293 cells, Vero cells, etc.) within which they will associate to form the virions. Ligands and antigens can be attached to, or incorporated into, the virions by known methods (see, e.g., U.S.
10 Patents 5,965,541, 5,962,311, 5,846,782, 5,770,442, 5,731,190, 5,712,136, and 5,559,099). Of course, where the nucleic acid(s) are included within a viral genome, the genome will be packaged within the virion during syntheses. Conversely, where at least one nucleic acid is extragenomic, it is included within the complex by admixing it with the virion under suitable conditions, along with
15 other components of the complex, such as liposomes (see, e.g., U.S. Patent 5,928,944).

 The virions within the complex can be homogeneous, in which the antigens, ligands, capsids and nucleic acids of each member are identical or substantially identical. In other applications, the complex can be heterogeneous
20 (i.e., a "library"). Indeed, the invention provides a library including a plurality of complexes, each comprising a virion as described above and at least a first nucleic acid encoding a first non-native antigen. The library is heterogeneous in that antigens of at least two of the plurality of the complexes are different. Of course, the virions within the library also can include ligands and other nucleic acids as
25 described above (e.g., encoding antigens, cytokines, or other factors of interest). Typically, the library is constructed by generating a random or semirandom population of putative antigens that are variously associated with the virion as described above. For example, the putative antigens can be generated by
30 proteolysis of proteins derived from a desired pathogen, the products of which can be fused to the capsid or to bi-specific molecules (as appropriate). Alternatively, mRNA or genomic DNA libraries from the desired pathogen can be randomly amplified, or digested, to result in fragments that can be subcloned into vectors suitable for inclusion within the complex. For association with the virion, for example, the fragments can be cloned in-frame with viral capsid proteins
35 (including truncated derivatives thereof) to generate chimeric capsid proteins containing antigenic domains. Similarly, the fragments can be cloned so as to be

operably linked to the promoter suitable for expression within the desired immune effector cells, as described above.

5 The inventive complex (or library) can be used to infect or transduce cells, typically immune effector cells. For delivery into a host animal, the complex (or library) can be incorporated into a suitable carrier to form a pharmaceutical or pharmacological composition. As such, the complex can be formulated and/or administered with a pharmacologically acceptable carrier (e.g., a pharmaceutically-acceptable carrier). Any suitable carrier is within the scope of the invention. The exact formulation, of course, depends on the nature of the
10 desired application (e.g., cell type, mode of administration, etc.), and many suitable formulations are known in the art (see, e.g., U.S. Patent 5,559,099). Of course, the pharmaceutical composition can include other constituents, such as, for example, other agents that activate or enhance an immune response (e.g., (complete) Freund's reagent).

15 The complex, library, and pharmaceutical composition of the present invention are useful for eliciting immune responses within a desired immune effector cell, typically an APC. Thus, the invention provides a method of eliciting such a response using a complex comprising a virion and a first nucleic acid encoding a first non-native antigen. The immune response can be or comprise
20 presentation of at least one of the antigens as an MHC-I-constrained moiety (an "MHC-I response") or as an MHC-II-constrained moiety (an "MHC-II response"). Preferably, the method results in both MHC-I and MHC-II responses. To promote both types of responses, preferably the virion has at least one second non-native antigen displayed on its surface, in addition to including the nucleic acid encoding
25 the first antigen.

The method can be employed *in vivo*, typically within a mammal, or *ex vivo* or *in vitro* on isolated immune effector cells. For *in vitro* application, suitable cells (preferably APCs) can be isolated from the skin, spleen, bone marrow, other lymphoid organs, lymph nodes, or blood using methods known in the art (see, e.g.,
30 Unanue, *Fundamental Immunology*, Third Edition, Paul (ed.), Raven Press, Ltd.: New York., pp. 119-21 (1993); U.S. Patent 5,962,318). In other protocols, peripheral blood monocytes can be isolated and cultured to mature them into dendritic cells (see, e.g., Rossi *et al.*, *Immunol. Lett.*, 31(2), 189-97 (1992)). After isolation and purification, the cells can be exposed to the inventive complex (or
35 library) and maintained under conditions sufficient for them to develop an immune response (typically, incubation for about a day or two under appropriate culture conditions). To enhance antigen presentation, preferably the cells also are exposed

to one or more activation factors (such as the cytokines discussed above). Such factors can be delivered exogenously, for example in the medium in which the cells are cultured. Alternatively, where the complex includes a nucleic acid encoding such factors, its expression within the cells can effectively deliver the factor to the cells. In any event, following a suitable incubation, the cells can be monitored to assess their immune response by any suitable method (e.g., flow cytometry, FACS, elispot analysis, etc.). Thereafter, the cells can be propagated or maintained as desired. Such cells can be reintroduced into mammals *in vivo* for presenting the MHC-I and/or MHC-II antigens to immunize the mammal against the antigen(s) presented to the immune effector cells.

Where a library (such as described above) is employed, the method affords the ability to assess the antigenicity of at least one "test," or putative, antigen. The method is conducted similarly as described above, except that the relative strengths of the response to the test antigen(s) are compared within the population of cells. Typically, after exposure to the library, the cells are subjected to subcloning (e.g., by limiting dilution), plated separately, and then expanded before assessing the strength of the response to the library. Colonies exhibiting a strong response to the antigen can be analyzed to determine the identity of the antigen, which then can be employed as a vaccine.

When the method is applied *in vivo*, the invention provides a method of inoculating or immunizing an animal. In accordance with the method, a complex (or library), such as is set forth above, is introduced into the mammal under conditions sufficient for the mammal to mount an immune response to the antigens. While many methods of inoculation are known in the art, subdermal or subcutaneous injection is favored for many applications. For maximally targeting immune effector cells, especially *in vivo*, preferably the complex includes at least one ligand displayed on the surface of the virion, as described above, recognizing an epitope present on a desired type of immune effector cell, preferably an APC. The presence of the ligand permits the complex to be targeted preferentially to the immune effector cells. Also, preferably the virion is further engineered (as discussed above) to reduce any tropism that corresponding wild-type viruses might exhibit towards non-immune effector cells, to maximally direct the complex to the desired immune effector cells. To heighten the response of the immune effector cells within the mammal, preferably the complex further includes at least one nucleic acid sequence encoding a factor that activates the cell, such as those cytokines, CD40-L, or osteopontin, as described above. Expression of the nucleic acid, thus, activates the cell to heighten the immune response.

EXAMPLE

While one of skill in the art is fully able to practice the instant invention upon reading the foregoing detailed description, the following example will help
 5 elucidate some of its features. In particular, it describes the construction of an adenoviral vector having a non-native ligand recognizing an epitope present on an immune effector cell, a first nucleic acid encoding a non-native antigen, and a second nucleic acid encoding an activator of APCs. Of course, as this example is presented for purely illustrative purposes, it should not be used to construe the
 10 scope of the invention in a limited manner, but rather it should be seen as expanding upon the foregoing description of the invention as a whole.

The procedures employed in this example, such as gene cloning, vector manipulation, and cell culture are familiar to those of ordinary skill in this art (see, e.g., Sambrook *et al.*, *Molecular Cloning: A Laboratory Manual*, 2d edition, Cold
 15 Spring Harbor Press (1989)). As such, and in the interest of brevity, experimental protocols are not recited in detail.

To construct the vector, a sequence encoding an RGD motif is engineered into the fiber gene of a replication-deficient adenovirus so as to fuse it to the HI loop of the encoded fiber, as previously described (see U.S. Patent 5,965,541).
 20 The RGD motif targets the virus to dendritic cells by binding cell-surface heparin molecules. Additionally, a hemagglutinin (HA) tag is engineered into the chimeric fiber adjacent to the RGD motif, which facilitates purification of the virus. This construct can be engineered within a plasmid encoding the fiber gene, the sequence of which is known.

25 The nucleic acids are introduced into the E1 region of the adenoviral genome as a recombinant expression cassette cloned into a plasmid encoding the E1 region of the adenoviral genome. This cassette includes a bi-directional promoter that directs transcription of two coding polynucleotides in opposite directions. In one direction, the promoter is operably linked to the gene encoding osteopontin (Ono *et al.*, *Mol. Immunol.*, 32(6), 447-48 (1995)). In the other
 30 direction, the promoter is operably linked to a nucleic acid encoding a polypeptide "string of beads" antigen (see, e.g., Toes *et al.*, *Proc. Nat. Acad. Sci. (USA)*, 94(26), 14660-65 (1997)).

Each of the desired constructs within plasmids are then recombined back
 35 into the "master-vector" adenoviral backbone using standard *E. coli* transformation and manipulation techniques. The master vector then is transfected into packaging cells by standard protocols and incubated for about 5-7 days. Because of the

vector's altered tropism (by virtue of the manipulations to the fiber), it is desirable to employ a cell expressing a ligand that can bind the HA tag in the fibers. One such suitable cell line, derived from HEK-293 cells (i.e., 293-HA cells), is known in the art (see, e.g., International Patent Application WO 98/54346). Following
5 this initial incubation, the supernatant is collected and used to infect fresh packaging cells, which are again incubated for about 5-7 days. After several rounds of amplification, standard assays (e.g., Southern blots, hybridization, cell-binding, etc.) are used to analyze the resultant recombinant adenoviral vector.

A stock of the resultant vector then is exposed to cultured dendritic cells
10 under conditions to facilitate infection of the cells. Following several days, the cells are processed to determine that the vectors have, in fact, infected them. The cells then are assayed, e.g., by Northern hybridization and/or Western blot, to determine that the nucleic acids encoding the osteopontin and the string of beads have been expressed. Another population of the cells is assayed to demonstrate
15 that the string of beads is presented as an MHC-I-constrained epitope and that the HA epitope is expressed in a MHC-II-constrained manner. Yet another population of the cells is assayed for the effect of the osteopontin, e.g., by assaying for activation of the CD40 protein and/or for IL-12/IL-10 levels.

20 **INCORPORATION BY REFERENCE**

All sources (e.g., inventor's certificates, patent applications, patents, printed publications, repository accessions or records, utility models, world-wide web pages, and the like) referred to or cited anywhere in this document or in any drawing, Sequence Listing, or Statement filed concurrently herewith are hereby
25 incorporated into and made part of this specification by such reference thereto.

INTERPRETATION GUIDELINES

The foregoing detailed description sets forth "preferred embodiments" of this invention, including the best mode known to the inventors for carrying it out.
30 Of course, upon reading the foregoing description, variations of those preferred embodiments will become obvious to those of ordinary skill in the art. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and
35 equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law.

As used herein, singular indicators (e.g., “a” or “one”) include the plural, unless otherwise indicated. The term “consisting essentially of” indicates that unlisted ingredients or steps that do not materially affect the basic and novel properties of the invention can be employed in addition to the specifically recited ingredients or steps. In contrast, the terms “comprising” or “having” indicate that any ingredients or steps can be present in addition to those recited. The term “consisting of” indicates that only the recited ingredients or steps are present, but does not foreclose the possibility that equivalents of the ingredients or steps can substitute for those specifically recited.

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WHAT IS CLAIMED IS:

1. A complex comprising (a) a virion having a surface and a lumen and comprising viral capsid proteins, (b) at least one non-native ligand displayed on the surface, which at least one ligand recognizes an epitope present on an immune effector cell, and (c) at least one first nucleic acid encoding at least one first non-native antigen.
2. The complex of claim 1, wherein at least one ligand recognizes a protein on an antigen presenting cell.
3. The complex of claim 1, wherein at least one ligand recognizes CD-40.
4. The complex of claim 1, wherein at least one ligand comprises an RGD motif or three or more tandem lysine and/or histidine residues.
5. The complex of claim 1, wherein an antigen is a gene product from a pathogen or a malignant cell.
6. The complex of claim 1, wherein an antigen is a synthetic polypeptide having from about 1 to about 15 antigenic domains.
7. The complex of claim 1, further comprising at least one non-native second antigen.
8. The complex of claim 7, wherein at least one first antigen is the same as at least one second antigen.
9. The complex of claim 7, wherein the virion comprises at least one chimeric protein comprising at least one first domain derived from a viral capsid protein and at least one second domain comprising at least one second antigen or at least one ligand.
10. The complex of claim 1, further comprising a liposome.
11. The complex of claim 1, wherein the virion is non-enveloped.
12. The complex of claim 1, wherein the virion elicits less virion-specific immunogenicity in a host animal than does a corresponding wild-type virion.
13. The complex of claim 1, wherein the virion comprises an adenoviral capsid.
14. The complex of claim 1, wherein the first nucleic acid comprises a viral genome.
15. The complex of claim 1, wherein the nucleic acid is expressed in an immune effector cell.

17. The complex of claim 16, wherein at least one polypeptide comprises a domain derived from CD40-L or osteopontin.

19. A method of inoculating a mammal, the method comprising introducing the complex of claim 1 into a mammal under conditions sufficient for the mammal to mount an immune response to at least one first non-native antigen.

21. The method of claim 19, wherein the mammal comprises an immune effector cell, and wherein at least one immune response comprises an MCH-1 response within the immune effector cell.

23. The method of claim 19, wherein the complex comprises at least one second nucleic acid sequence encoding at least one polypeptide that activates an immune effector cell, which is expressed within the mammal under conditions sufficient to activate the immune effector cell.

25. The method of claim 19, wherein the polypeptide is a cytokine.

27. The method of claim 26, wherein the complex further comprises at least one non-native ligand displayed on the surface, which recognizes an epitope present on an immune effector cell.

28. The method of claim 26, wherein the mammal comprises an immune effector cell, and wherein at least one immune response comprises an MCH-1 response within the immune effector cell.

29. The method of claim 26, wherein the mammal comprises an immune effector cell, and wherein at least one immune response comprises an MCH-2 response within the immune effector cell.

30. The method of claim 26, wherein the complex comprises at least one second nucleic acid sequence encoding at least one polypeptide that activates an immune effector cell, which is expressed within the mammal under conditions sufficient to activate the immune effector cell.

31. The method of claim 26, wherein at least one polypeptide comprises a domain derived from CD40-L or osteopontin.

32. The method of claim 26, wherein the polypeptide is a cytokine.

33. A library comprising a plurality including at least two of complexes of claim 1, wherein at least one of the first non-native antigens of at least two of the plurality of the complexes are different.

34. The library of claim 33, wherein at least one of the complexes further comprises at least one second non-native antigen.

35. A library comprising a plurality including at least two complexes, each of which comprises (a) a virion having a surface and a lumen and comprising viral capsid proteins and (b) at least one first nucleic acid encoding at least one first non-native antigen, wherein at least one of the first non-native antigens of at least two of the plurality of the complexes are different.

36. The library of claim 35, wherein at least one of the complexes further comprises at least one second non-native antigen.

37. The library of claim 35, wherein at least one of the complexes further comprises at least one non-native ligand displayed on the surface, which recognizes an epitope present on an immune effector cell.

38. A method of assessing the antigenicity of at least one test antigen, the method comprising (a) exposing the library of claim 33 to a population of immune effector cells, the library containing least one test antigen, (b) maintaining the cells under conditions such that the cells develop a response to the test antigen, and (c) assessing the relative strength of the response of the cells to the test antigen.

39. A method of assessing the antigenicity of at least one test antigen, the method comprising (a) exposing the library of claim 35 to a population of immune effector cells, the library containing least one test antigen, (b) maintaining

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the cells under conditions such that the cells develop a response to the test antigen, and (c) assessing the relative strength of the response of the cells to the test antigen.

40. A pharmaceutical composition comprising (a) a complex which
5 comprises (i) a virion having a surface and a lumen and comprising viral capsid
proteins, (ii) at least one first nucleic acid encoding at least one first non-native
antigen, and (b) a physiologically-acceptable carrier.

41. The pharmaceutical composition of claim 40, wherein the complex further comprises at least one second non-native antigen

10 42. The pharmaceutical composition of claim 40, wherein the complex further comprises at least one non-native ligand displayed on the surface, which recognizes an epitope present on an immune effector cell.

43. The pharmaceutical composition of claim 40, wherein the complex
comprises at least one second nucleic acid sequence encoding a polypeptide that
15 activates an immune effector cell.

ABSTRACT

The present invention provides a complex that includes a virion having a ligand that recognizes an epitope present on an immune effector cell surface and at least a first nucleic acid encoding a first non-native antigen. The invention also
5 provides a library including a plurality of such complexes, in which antigens of at least two of the plurality are different. Using such reagents, the invention provides a method of precipitating an immune response within an immune effector cell, wherein such a complex is delivered to the cell under conditions sufficient for the cell to mount an immune response to the antigen. When applied *in vivo*, the
10 method can serve to immunize an animal from the pathogen. Moreover, using a library including a plurality of complexes, which contains at least one test antigen, the invention provides a method of assessing the antigenicity of the test antigen.

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